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## (54) Cellular telephone systems

(57) A method is disclosed enabling a subscriber to an AMPS/D-AMPS network (D), such as in the U.S.A., to roam into networks (A, B, C) of a GSM system. A primary one of the GSM networks (e.g. A) concludes a cooperation arrangement with the AMPS/D-AMPS network (D). An AMPS/D-AMPS subscriber wishing to roam into the GSM network is provided with a temporary GSM smartcard bearing a number (IMSI) identifying the subscriber as visiting the primary network (A) but also as being registered with the AMPS/D-AMPS network (D). If that subscriber activates a handset in the primary network (A) with that smartcard, the network recognises the subscriber as an AMPS/D-AMPS subscriber and, via a communications link (62), extracts subscriber data from an HLR (58) in the AMPS/D-AMPS network and stores this in the VLR associated with the appropriate cell in the primary network (A). Calls can then be made to and from the subscriber and are billed to the subscriber by the AMPS/D-AMPS network (D) via the communications link.

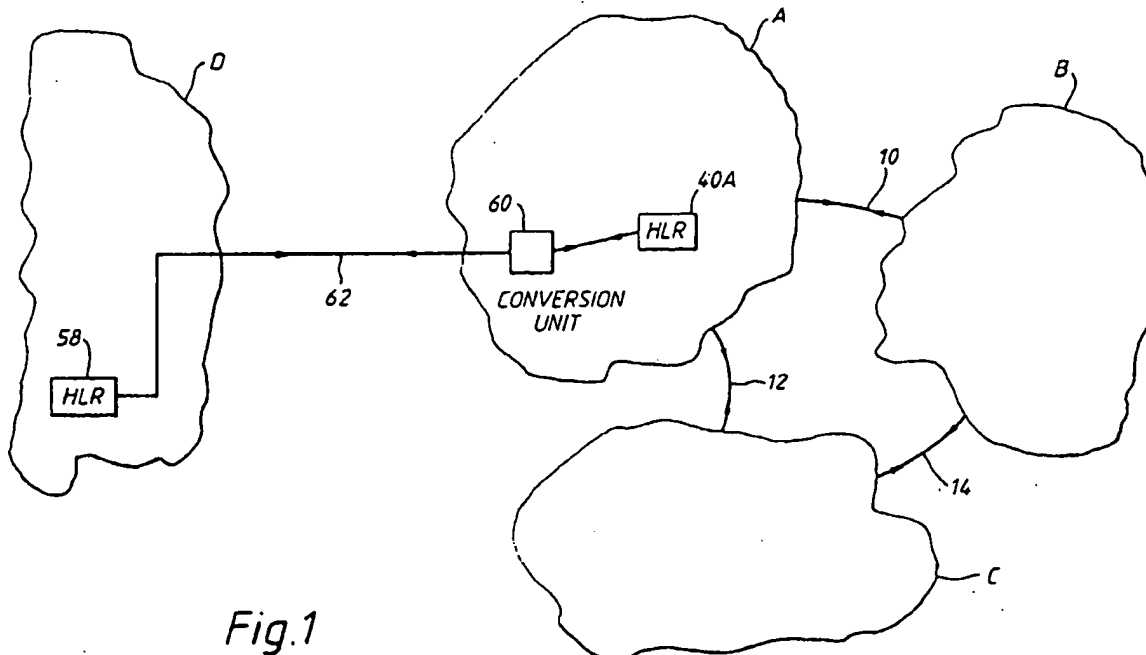


Fig.1

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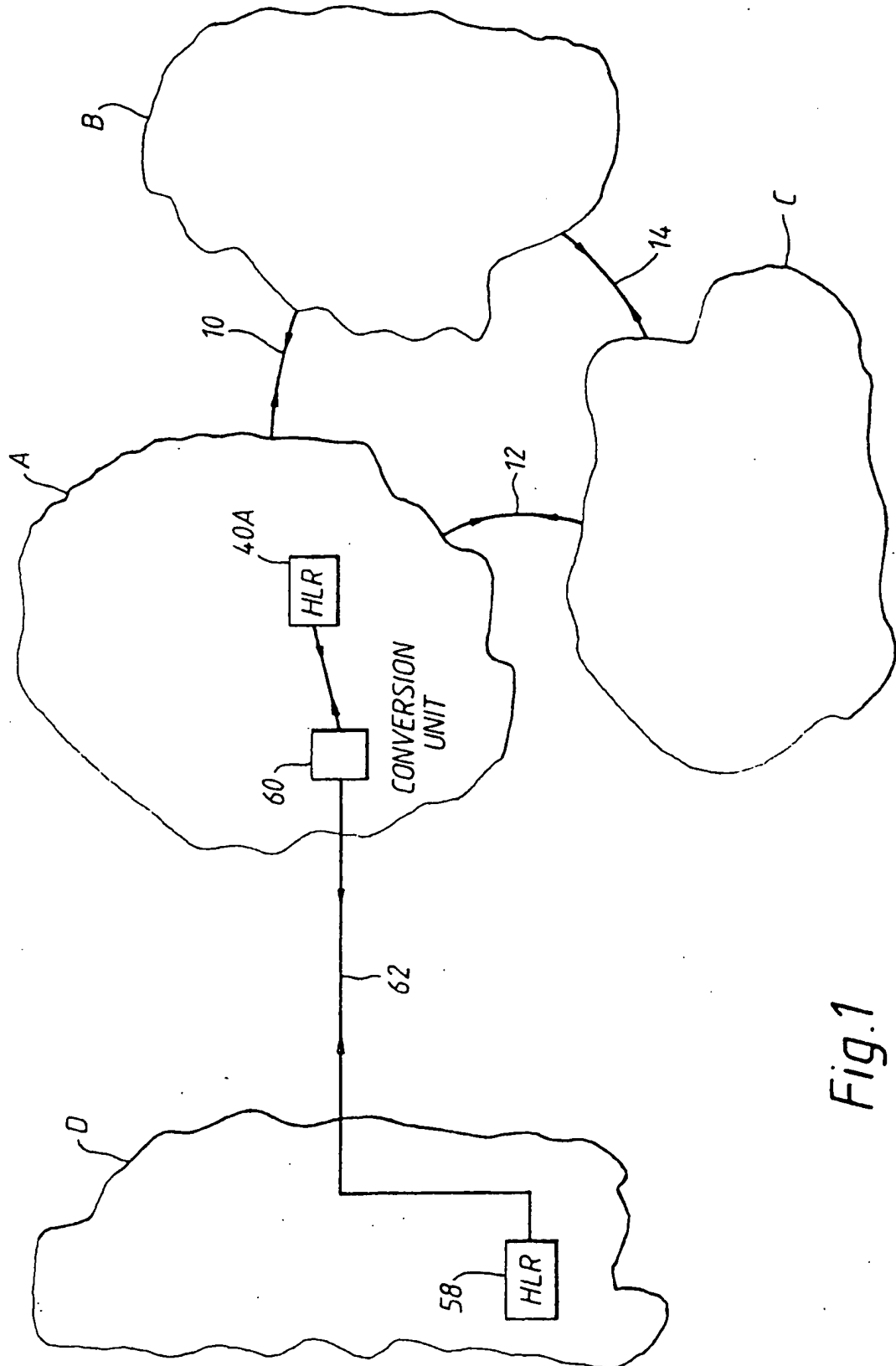


Fig.1

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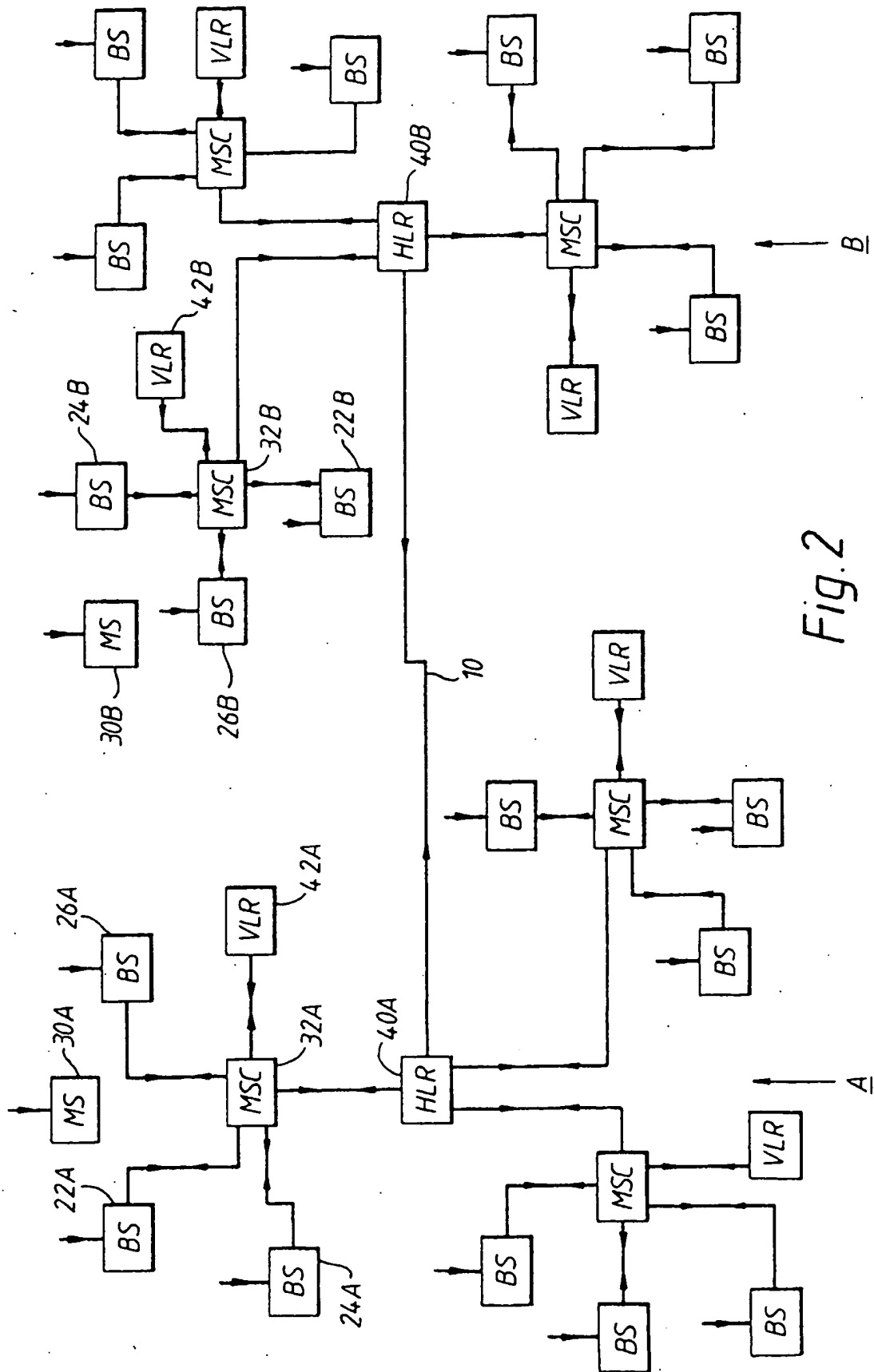


Fig. 2

## TELECOMMUNICATION SYSTEMS AND METHODS

The invention relates to telecommunication systems and methods by means of which a plurality of subscribers may communicate with each other. Embodiments of the invention to be described in more detail comprise such telecommunications systems in the form of telephone networks and more especially such systems involving mobile telephones (such as in a cellular network). Mobile telephones may be hand-portable or they may be mounted (permanently or otherwise) in a vehicle (such as a land vehicle - a car or train, for example) or a ship or aircraft. These and other examples of mobile telephones are referred to in this specification and claims as "mobiles".

A significant number of separate cellular telephone systems exist throughout the world. In North America, there is a system made up of a large number of separate cellular networks operating in accordance with the AMPS standard or the D-AMPS standard, and AMPS-standard networks are also used in other countries in the world. In a number of European countries, cellular telephone networks operating to the GSM (digital) standard are now in operation, or rapidly coming into operation, to form a GSM system. GSM networks are also in operation in other

countries in the world. It is desirable that a subscriber to a particular cellular network in a system (the "home" network) is able to roam to (that is, gain telephone service from) a different cellular network (a "visited" network) in the system if and when the subscriber is temporarily located in the visited network. Clearly, if subscribers visit an area covered by a different cellular network within the system, they could apply to subscribe to the visited network in the same way as any new subscriber. However, this application process necessitates checking the identity of the applicant and such details as credit-worthiness. This process may be complicated and long drawn-out and susceptible to fraud, particularly if the subscriber originates from another country. It is therefore desirable for subscribers to a home network to be able to roam to a visited network, such as in another country, and to be able to make and receive calls via the visited network after the minimum of formalities and with the billing of all such calls and other charges being made to them by their home network. In this way, the operator of the visited network incurs the minimum financial liability and there is maximum convenience for the subscriber. There is also the advantage that calls to roaming subscribers can be made to them via their usual telephone number - that is, the telephone number which they have within their own home

network. Such roaming is possible for subscribers within the North American AMPS/D-AMPS system, and it is also possible within the European GSM system.

It would be desirable to extend this roaming process.

According to the invention, there is provided a method of operating a cellular telephone system having local subscribers to the system ("the main system") who are respectively identified to the main system by means of respective subscriber identification numbers, these numbers being used within the main system to record the location therein of each subscriber within the main system for receiving and initiating calls and for recording associated billing information, the method comprising the steps of: providing similar identification numbers for distant subscribers who are not subscribers of the main system but are subscribers to a second cellular telephone system, each latter number being input into the main system when visited by the distant subscriber, such number not only being used within the main system to record the location therein of the subscriber for receiving and initiating calls and for recording associated billing information but also identifying the subscriber as being a subscriber subscribing to the second cellular telephone system; providing inter-system communications means

between the two systems so that calls to a distant subscriber visiting the main system are routed via the second system and the communication means and the main system and thence to the location in the latter of the distant subscriber which is identified within the main system by that subscriber's identification number, and so that calls initiated by that distant subscriber are routed via the main system; and transmitting billing information associated with calls received and/or initiated by the visiting distant subscriber to the second system and via that system to the distant subscriber.

According to the invention, there is further provided a cellular telephone arrangement, comprising a main cellular telephone system having local subscribers to the system who are identified to the system by means of respective subscriber identification numbers to be input into the system, these numbers being used within the system to record the location of each subscriber within the system for receiving and initiating calls and for recording associated billing information; reading means within the main system for reading subscriber identification numbers input into the system by a distant subscriber who is not a subscriber to the main system but is a subscriber to a second cellular telephone system, such subscriber identification number identifying the distant subscriber

as being a subscriber to the second system but temporarily authorised within the main system and being used within the main system to record the location of the distant subscriber within the main system for receiving and initiating calls and for recording associated billing information; inter-system communication means providing communication between the main system and the second system so that calls to the distant subscriber in the main system are routed from the said other system and via the communication means and the main system and thence to the location of the distant subscriber therein, and so that calls initiated by that distant subscriber are routed via the main system; and billing means for transmitting billing information associated with calls received or initiated by the visiting distant subscriber to the second system and thence via that system to the subscriber.

According to the invention, there is also provided a cellular telephone arrangement, comprising: a primary cellular telephone network and a distant cellular telephone network; the primary network having local subscribers to that network who are respectively identified to that network by means of respective subscriber identification numbers; the distant network having distant subscribers to that network who are respectively identified to that network by means of



respective subscriber identification numbers; each network having a respective home location register ("HLR") for storing subscriber data relating to each subscriber to that network including the respective subscriber identification numbers; each network having a respective plurality of visitor location registers ("VLR's") each corresponding to a particular cell of the network; means within each network for responding to the input into a particular cell of that network of the subscriber identification number of a subscriber to that network to access the corresponding stored subscriber data from the HLR of that network and to store it temporarily in the VLR of that cell for use in relation to calls made to or from that subscriber via that cell and for recording associated billing information; means for storing, in the HLR of the primary network, data ("visiting subscriber data") relating to a distant subscriber intending to visit the primary network, the visiting subscriber data including a visiting subscriber identification number provided to the visiting distant subscriber for that purpose and also including corresponding address data for addressing at least some of the subscriber data relating to the visiting distant subscriber which is stored in the HLR of the distant network; means for storing, in the HLR of the distant network, address data relating to the visiting distant subscriber for addressing at least some of the

visiting subscriber data stored in the HLR of the primary network; means responsive to the input into a cell of the primary network of the visiting subscriber identification number for accessing the corresponding visiting subscriber data in the HLR of the primary network; means responsive to the corresponding address data in the HLR of the primary network for accessing at least some of the subscriber data relating to that subscriber and stored in the HLR of the distant network; means for storing the accessed data from the HLR's of both networks in the VLR of the said cell for use in relation to calls to and from the visiting distant subscriber via that cell and for recording associated billing information; means in the distant network responsive to calls made to the visiting distant subscriber via the distant network to route such calls to the visiting distant subscriber via the distant network and the main network using the data temporarily stored in the VLR of the cell where the visiting distant subscriber is temporarily located; means in the primary network responsive to a call made by the visiting distant subscriber to route that call via the cell where the visiting distant subscriber is temporarily located and via the main network; and means in the primary network and responsive to the data temporarily stored in the VLR of the cell where the visiting distant subscriber is temporarily located for transmitting the recorded billing

information to the distant network for the account of the distant subscriber.

An arrangement of cellular telephone systems embodying the invention, and methods of telephonic communication via different cellular telephone systems according to the invention, will now be described, by way of example only, with reference to the accompanying drawings in which;

Figure 1 is a diagrammatic drawing of one of the arrangements; and

Figure 2 is a diagrammatic drawing of two GSM networks for use in explaining the operation of the arrangement of Figure 1.

Figure 1 diagrammatically shows three (in this example) GSM cellular networks A, B and C located in different European countries (in practice, there may be more than one GSM network in any particular country). Network A may, for example, be the VODAFONE (trade mark) network in the United Kingdom, and networks B and C could, for example, be networks in Germany and France respectively. These networks are shown as being interconnected by communications and control links indicated diagrammatically at 10, 12 and 14. The GSM standard,

common to all the networks A,B and C, is such that a subscriber to network A in the United Kingdom can roam to either of networks B and C and make and receive calls with no previous formality. When roaming in this way and making and receiving calls, the subscriber is billed for all charges relating to such calls through the home network A in the usual way. Callers to the subscriber use the subscriber's usual telephone number. The visited network used by the roaming subscriber may levy handling charges of its own. Any such handling charges are automatically passed back to the home network A which charges them out to the subscriber, the home network A being responsible, thereafter, for reimbursing the visited network B or C. The visited network is therefore not involved in registering the roaming subscriber or checking the subscriber's credit-worthiness.

Also shown in Figure 1 is an AMPS or a D-AMPS network D which in this example is assumed to be located in the United States of America. There are a large number of separate such networks in the U.S.A. Until recently, roaming between them was either not possible or difficult or restricted - that is, it was not possible for a subscriber to one of them to roam to another one and to make and receive calls via the visited network without first going through an application procedure substantially

as though that subscriber were a new subscriber. Roaming between different AMPS or D-AMPS networks is now possible.

The network arrangement now to be described in more detail enables the above-mentioned roaming capability to be extended so that (a) a subscriber to an AMPS/D-AMPS network (such as in the United States system) can roam into the area covered by the GSM system (such as networks A,B and C), and (b) a subscriber to a network (such as networks A,B and C) in the GSM system can roam into the area covered by the United States AMPS/D-AMPS system. In each case, calls to and from the roaming subscriber are made via the visited network, and all financial charges involved in such calls are billed automatically to the subscriber via the subscriber's home network. Calls to the roaming subscriber are made using the subscriber's usual telephone number.

Initially, roaming by a subscriber to an AMPS/D-AMPS network into one of the networks (networks A,B and C) of the GSM system will be described.

Figure 2 diagrammatically explains the operation of the GSM networks of Figure 1 in simplified form. Only networks A and B are shown in Figure 2. Network A has a number of base stations (BS) such as BS 22A, 24A and 26A.

Each base station corresponds to a respective cell of the network and receives calls from and transmits calls to a subscriber in that cell by radio. Such a subscriber (MS) is shown at 30A. The base stations are arranged in groups and each group of base stations is controlled by a mobile service switching centre (MSC), such as MSC 32A for BS 22A to 26A. As shown in Figure 2, the network also has two other MSC's 34A and 36A, each of which is shown as controlling three further BS's. In practice, the network will of course incorporate more MSC's and BS's than shown in Figure 2.

Each subscriber to the network is provided with a smartcard (referred to as a SIM card where SIM means "subscriber identification module"). The SIM card identifies the subscriber to the network. The SIM card is pre-programmed with a unique identification number, the "International Mobile Subscriber Identity" (IMSI) which is not visible on the card and is not known to the subscriber. The subscriber is of course also issued with a publically known number, that is, the subscriber's telephone number, by means of which calls to that subscriber are initiated by callers. This number is the MSISDN ("Mobile Station International IDSN Number").

The network includes a "home location register" (HLR) 40A

which, for each subscriber to the network, stores the IMSI and the corresponding MSISDN together with other subscriber data. When a subscriber wishes to activate a mobile in a network (so that it may make or receive calls subsequently), the subscriber places the SIM card in a card reader associated with the mobile (MS 30A in this example) and enters an identification number (PIN). Provided that the entered PIN is found to be correct for that particular SIM card, MS 30A transmits the IMSI (read from the card) to the base station (BS 22A in this example) associated with the particular cell in which the MS is located. BS 22A transmits this IMSI to the MSC 32A. MSC 32A now accesses the appropriate location in the HLR 40A and extracts the corresponding subscriber MSISDN and other subscriber data from the appropriate storage location, and stores it temporarily in a location in a "visitor location register" (VLR) 42A. In this way, therefore the particular subscriber is effectively registered with a particular MSC (MSC 32A), the subscriber's information being temporarily stored in the VLR (VLR 42A) associated with that MSC.

Each of the other MSC's of the network (MSC 34A and MSC 36A) has a respective VLR associated with it and operates in the same way as already described when a subscriber activates an MS in one of the cells corresponding to one of the BS's controlled by that MSC.

When the subscriber wishes to make a call using MS 30A, having already inserted the SIM card into the reader associated with this MS in the manner described, the subscriber enters the telephone number of the called party in the usual way. This information is received by BS 22A and the call is then routed to the called party via the MSC 32A. By means of the information held in the VLR 42A, MSC 32A can associate the call with the particular subscriber and thus record information for charging purposes.

Similarly, when a calling party (whether a subscriber within the network or outside it) makes a call for the subscriber using MS 30A, MSC 32A is able to route this call to MS 30A via BS 22A using the information relating to that subscriber and to MS 30A which is temporarily stored in VLR 42A.

The foregoing is intended to be merely a simplified description of the normal operation of a GSM network. In practice, other procedures will also be carried out. In particular, an authentication procedure will take place when a subscriber activates a mobile.

Also shown in Figure 2 is the GSM network B. Items in network B corresponding to those in network A are



similarly referenced, but with the suffix "B" instead of "A". Of course, the network B is likely to have a different arrangement and number of MSC's and BS's but operates in the same way as network A.

As explained above, for a subscriber to network A, the respective IMSI and MSISDN and other relevant data particular to that subscriber will be stored in HLR 40A (Fig. 2). If that subscriber now roams to network B and activates a mobile such as MS 30B in that network, the procedure described above is substantially repeated. Thus, the subscriber inserts the SIM card into the card reader in MS 30B and enters the PIN. Assuming that the entered PIN is found to be correct for that particular SIM card, the mobile transmits the IMSI from the card to the adjacent base station (BS 22B) and thence to MSC 32B. However, MSC 32B will now recognise, from the structure of the IMSI, that the subscriber is not a subscriber to network B but is a subscriber to network A. Therefore, MSC 32B will access HLR 40A instead of HLR 40B (via interconnection 10, see Figure 1). The subscriber's information, including the relevant MSISDN and other subscriber data, will be accessed and temporarily stored in VLR 42B. All this information is thus ready for use in processing calls to or from MS 30B. Any charging information associated with any such calls can then be

associated with the subscriber information in VLR 42B and eventually transmitted back to HLR 40A and then billed to the subscriber.

If a calling party wishes to make a call to the visiting subscriber using MS 30B, the call would initially be routed to network A (because this network would be the network identified by the subscriber's publically known telephone number which the calling party would use). The call would interrogate HLR 40A which would thus produce information that a copy of the subscriber's data was temporarily stored in VLR 42B, thus indicating, of course, that the subscriber had roamed to network B. Via the link 10 (Figure 1), network A interrogates network B to request a "roaming number". This is in effect a temporary telephone number for the subscriber, being a number appropriate to network B. This roaming number can now be used to route the calling party's call to network B and thence to MS 30B. The calling party would of course not be aware of this roaming number or of the transferring process.

Again, the foregoing description of roaming between different GSM networks is intended to be only a brief and partial description only.

In accordance with a feature of the invention now to be described, however, it is possible for a subscriber to an AMPS or D-AMPS, such as network D (Fig. 1), to roam into one of the GSM networks A,B,C to make and receive calls via the visited GSM network, and to be billed for all associated charges via the home network, network D.

In accordance with this feature of the invention, any such subscriber to network D intending to roam into the area of one or more of the GSM networks A,B,C would apply to the operator of network D who would provide the subscriber with a GSM SIM card. This would be pre-programmed with an IMSI identifying the subscriber as a subscriber to a particular one of the GSM networks such as network A, the operator of network D having entered into a commercial arrangement with the operator of network A for this purpose. In addition, however, the IMSI would include further data which would enable network A to identify the subscriber as in fact being a subscriber to network D.

While roaming, the subscriber will wish to continue to use the same publically known telephone number as used within home network D. Using a home location register (HLR) 58 (Figure 1), the operator of network D therefore associates the subscriber's normal telephone number with a storage location in the HLR 40A (of network A) in which will be

stored the IMSI on the SIM card just issued and other subscriber information. The HLR 58 of network D has no knowledge of this information, simply being aware that a SIM card has been issued to a particular network D subscriber and that certain GSM-specific data relating to that SIM card is stored in a particular location in HLR 40A of network A.

In explaining the further operation, it will initially be assumed that the subscriber now arrives within the area of network A. The subscriber requires the use of a GSM handset which could be rented perhaps from the operator of network D or on arrival within the area of network A. Upon entry of the subscriber's SIM card into the rented GSM handset (which will initially be assumed to be MS 30A, Fig. 2), and entry of the appropriate PIN, the associated base station (BS 22A) will transmit the corresponding IMSI data to MSC 32A. From the IMSI data, network A recognises the subscriber as being a subscriber to network D. Therefore none of the subscriber's data (the GSM-specific data such as security and authentication data) will be stored in HLR 40A of network A but other subscriber data (e.g. data identifying the subscriber's telephone number, charging address etc) will be stored in HLR 58 in network D. By means of a conversion unit 60 (Fig. 1), network A then transmits a signal along a communication link 62 to

network D and interrogates its HLR 58 in order to access the required subscriber data.

In this way, the appropriate storage location in HLR 58 is accessed and the subscriber data transmitted back to network A via communication link 62 and conversion unit 60 and thence to the appropriate VLR, VLR 42A (Figure 2) in this example. If the subscriber now wishes to make a telephone call via MS 30A, this proceeds in the manner already described above with reference to Figure 2. Charging information associated with the call is stored in VLR 42A and eventually transmitted back to network D such as via conversion unit 60 and communication link 62 or in any other suitable way such as by magnetic tape. Network D then eventually bills the subscriber for the call in the usual way. For handling the call, the operator of network A may add a handling charge and this will be fed back to network D as well.

A calling party wishing to make a call to the subscriber via MS 30A will initiate the call using the subscriber's normal network D telephone number. In the normal way, network D responds to such a call by interrogating HLR 58. The storage location corresponding to that particular subscriber now contains information to the effect that the subscriber is located within the area of network A.

Accordingly, network D now requests a "roaming number" from network A, again via conversion unit 60 and communication link 62. This roaming number request is transmitted to VLR 42A which responds by returning a roaming number identifying MS 30A to network D. This roaming number now enables network D to route the call to MS 30A via network A.

The above description assumes that networks A and D have concluded a suitable commercial arrangement and have set up the communication link 62.

It will now be assumed that the same commercial arrangement exists (that is, between network A and D), and also the same communication link 62, but that the roaming subscriber is now visiting network B rather than network A. It will further be assumed that the roaming subscriber's rented GSM handset is MS 30B (Fig. 2).

When the subscriber enters the SIM card into the reader of MS 30B, together with the corresponding PIN number, the subscriber's IMSI is transmitted via the associated base station (BS 22B in this example) to MSC 32B. As far as network B is concerned, the IMSI information will identify the subscriber as being a subscriber to network A; network B will not or need not be aware that the subscriber is

ultimately a subscriber to network D. MSC 32B will therefore access the HLR of network A, that is, HLR 40A. As already explained, HLR 40A will only in fact store the GSM-specific part of the subscriber's data but also stores information identifying the appropriate location in HLR 58 in network D where the remainder of the subscriber's data is held. Upon receipt of the interrogation from network B, network A is therefore able to identify the subscriber (from the IMSI information transmitted from network B) and accesses the subscriber's data both from HLR 40A and from HLR 58. This subscriber's data is transmitted over communications link 10 (Fig. 1) from network A to network B and stored in the appropriate location in VLR 42B.

The subscriber can now make calls from MS 30B in the manner already explained with reference to Figure 2. The calling information is received by BS 22B and then routed by MSC 32B to the called number (which may, of course, be another number within network B, another number within any of the other networks, or a number within a PSTN). Information concerning the call (call number and duration etc.) is stored in VLR 42B. Network B then eventually uses this information to bill network A for the call. Using the information within HLR 40A, network A then passes the billing information onto network D whose operator bills it to the subscriber. This process may

involve the addition of handling charges by the operators of either one or both of networks A and B.

If a calling party wishes to make a call to the roaming subscriber via MS 30B, the call is, as before, initiated by use of the subscriber's home telephone number - that is, the public telephone number which the subscriber has within network D. The call causes interrogation of the appropriate location in HLR 58 (and Figure 1) and this produces information to the effect that the subscriber has roamed to network A; network D will be unaware that the subscriber has in fact roamed to network B. By means of the communication link 62, network D requests a roaming number from network A. From the information within HLR 40A, however, network A will be aware that the subscriber is not in fact present within network A but is within network B. In the manner already described above for normal GSM operation, network A now requests a roaming number from network B - that is, a number identifying MS 30B. Upon receipt, this roaming number can be processed in either of two different ways.

Firstly, network A can pass this roaming number directly back to network D via the communication link 62. Using this roaming number, it is now possible for the call to be routed by network D directly to network B and thence to MS 30B. As far as network B is concerned, the call is a call



to a visiting network A subscriber. Network B may wish to levy a handling charge for the call and this charge would be passed back to network A which would then bill it to network D and thence eventually to the subscriber. At the same time, the operator of network A could add on its own handling charge which would be billed to the subscriber by network D. With this method of operation, the call from the calling party is routed directly to network B from network D. The operator of network A is therefore not directly informed of the call. This method of operation may be open to confusion and mis-use.

In the second possible mode of operation, the roaming number provided by network B and identifying MS 30B is not passed directly back by network A to network D. Instead, the roaming number from network B is stored by network A and then an associated network A roaming number is generated and transmitted over the communications link 62 to network D. Network D uses this network A roaming number to direct the call over communications link 62 to network A. Network A in turn uses the stored network B roaming number to pass the call on to MS 30B via network B. Handling charges from networks A and B are then generated and passed back to network D and thence to the subscriber in the manner already explained. This mode of operation may be more satisfactory in certain

circumstances in that network A is always aware of calls to and from the roaming subscriber, no matter which GSM networks is used for the call.

The arrangement described requires the existence of a suitable communications link 62. AMPS/D-AMPS networks within North America are now able to communicate with each other, to permit subscriber roaming between them, using a roaming signalling specification designated IS41. By means of IS41, subscribers can roam between AMPS/D-AMPS networks, calling charges being billed back to their home network in the manner explained above with reference to GSM networks A,B and C. Advantageously, therefore, communication link 62 can operate in accordance with IS41, the conversion unit 60 being operable accordingly. In this way, therefore, the signals received by network D along communications link 62 and relating to a network D subscriber who has roamed into one of the GSM networks A,B and C, are equivalent to signals which would be received by network D had the subscriber roamed to another AMPS/D-AMPS network. Communications link 62 could be a C.7 or X.25 network or the normal international telephone network.

The manner in which subscribers to one of the GSM networks (networks A,B and C for example) can roam into a network

(e.g. network D) of the AMPS/D-AMPS system will now be described.

It will initially be assumed that the operator of network A has entered into a commercial arrangement with the operator of network D (only) for this purpose.

A subscriber to network A intending to roam into the area of the AMPS/D-AMPS system will apply to the operator of network A who will register this fact against the subscriber's data in HLR 40A. The AMPS/D-AMPS system does not involve the use of SIM cards. However, telephone handsets used in the AMPS/D-AMPS networks incorporate a subscriber identification number (in addition to the publicly known telephone number). Therefore, the operator of network A would temporarily allocate the subscriber a subscriber identification number applicable to network D; for example, this number could be in a batch specifically allocated by the operator of network D to the operator of network A for this purpose. Network A stores this temporary number in HLR 40A in association with the subscriber's network A IMSI. HLR 58 in network D stores the subscriber's temporary network D identification number in association with data indicating that the subscriber is in fact a network A subscriber.

On arrival in the United States, the subscriber is provided with, or would previously have been provided with, a telephone handset carrying the temporary network D subscriber identification number.

Initially, it will be assumed that the visiting subscriber is present within network D and activates the telephone. In the normal way, applicable to AMPS/D-AMPS networks, the telephone sends out an appropriate signal to the base station of the cell in which it is located which recognises the telephone as being a normal network D telephone. The base station therefore accesses HLR 58 for the subscriber's data. HLR 58 will respond to the request by recognising that the subscriber is in fact a network A subscriber. It therefore addresses HLR 40A and accesses the subscriber's data which it temporarily stores and also passes it to the local VLR applicable to the cell where the telephone is presently located. The subscriber can now make calls in the usual way. Charging for such calls is accumulated by network D and eventually passed back to the operator of network A which will charge the subscriber in the normal way.

It will now be assumed that a calling party wishes to make a call to the subscriber (who, it is assumed, is temporarily present within network D). The calling party

will use the subscriber's normal network A telephone number. The call will therefore be received by network A and passed to HLR 40A which will recognise that the subscriber is in fact temporarily present within network D and will pass the call to that network. Assuming that the visiting subscriber's telephone handset is activated, HLR 58 will know the location of the cell in which the telephone is temporarily located and whose VLR will store the subscriber's data. Network D can thus pass a roaming number to network A which can now route the call to the subscriber. Charges for the call accumulated by network A will be billed to the subscriber in the usual way. If network D wishes to make any charges for passing the call on to the subscriber, these will be accumulated against the subscriber's data temporarily stored in network D and eventually passed to network A for onward charging to the subscriber.

The visiting subscriber may now roam to another AMPS/D-AMPS network - a network linked to network D via the above-mentioned roaming signal specification IS 41. The roaming subscriber will still have his temporary network D handset. If the subscriber now activates the telephone, the local AMPS/D-AMPS network will recognise the subscriber as a network D subscriber and, over the IS 41 link, will access HLR 58 in network D for the

subscriber's data. In turn, network D will access HLR 40A in network A for the subscriber's data. In this way, therefore, the local AMPS/D-AMPS network will receive the subscriber's data which will be stored in the local VLR applicable to the cell where the subscriber is temporarily located.

If the subscriber now makes a call, calling charges will be accumulated via the visited AMPS/D-AMPS network and will be passed back by that network, over the IS 41 link, to network D (because the visited network assumes that the subscriber is a network D subscriber). Network D will in turn pass the charges to network A (together with any of its own charges which it wishes to add). Network A will in turn eventually bill the subscriber (including any of its own charges as well).

A calling party wishing to call the subscriber will (as before) use the subscriber's network A telephone number. The call will be received by network A which will note that the subscriber is visiting the AMPS/D-AMPS system and will request a roaming number from network D. From the information within its HLR 58, however, network D will be aware that the subscriber is not in fact present within network D but is within another AMPS/D-AMPS network. Network D now requests a roaming number from this visited network.

Network D can now pass this roaming number directly back to network A via the communication link 62. Using this roaming number, the call can be routed by network A directly to the visited AMPS/D-AMPS network and thence to the subscriber's temporary telephone handset. As far as that network is concerned, the call is a call from a visiting network D subscriber. The visited network may levy a charge for the call and this will be passed back to network D which (after adding any charges of its own) would then bill it to network A which would in turn eventually bill it to the subscriber.

Alternatively, the roaming number provided by the visited AMPS/D-AMPS network can be temporarily stored by network D and, instead, an associated network D roaming number can be generated and transmitted over the communications link 62 to network A. Network A uses this network D roaming number to direct the call over communications link 62 to network D. The latter network in turn uses the temporarily stored roaming number for the visited AMPS/D-AMPS network to pass the call to the subscriber via that network. Again, handling charges from the AMPS/D-AMPS network are generated and passed back to network A and charged to the subscriber in the manner already described.

The foregoing operations concerning a visitor from the GSM system to the AMPS/D-AMPS system assume that the operator of one of the GSM networks (network A in the example considered) has concluded a commercial arrangement with one, only, of the AMPS/D-AMPS networks (network D in the example considered).

In an alternative mode of operation, however, the GSM network operator (for example, the operator of network A) can conclude a separate commercial arrangement with the operator of every AMPS/D-AMPS network, or at least all those AMPS/D-AMPS networks which the visiting GSM subscriber is likely to visit.

As before, the network A subscriber intending to roam into the AMPS/D-AMPS system will apply to the operator of network A who will register this fact against the subscriber's data in HLR 40A. The operator of network A temporarily allocates the subscriber a subscriber identification number which is applicable to the AMPS/D-AMPS system but is one in a batch specifically allocated for this purpose - and is such that it is recognised by every one of the AMPS/D-AMPS networks as being a number applicable to another AMPS/D-AMPS network. Therefore, network A stores this temporary number in HLR 40A in association with the subscriber's network A IMSI.



The HLR in each of the AMPS/D-AMPS networks stores the subscriber's temporary identification number in association with data indicating that the subscriber is in fact a network A subscriber.

It will now be assumed that the visiting subscriber is present within a network within the AMPS/D-AMPS system and activates the telephone. The local base station responds to activation of the telephone by accessing the local HLR for the subscriber's data. The HLR will respond to the request by recognising that the subscriber is in fact a network A subscriber and therefore addresses HLR 40A and accesses the subscriber's data which it then temporarily stores and also passes to the local VLR applicable to the cell where the telephone is presently located. The subscriber can now make calls in the usual way. Charging for such calls is accumulated by the visited network and eventually passed back to the operator of network A for onward billing to the subscriber.

A calling party wishing to make a call to the subscriber uses the subscriber's normal network A telephone number as before. The call is received by network A and passed to HLR 40A which recognises that the subscriber is in fact temporarily present within a particular AMPS/D-AMPS network and passes the call to that network. The latter

network's local HLR will know the location of the cell in which the telephone is temporarily located and his VLR will be storing the subscriber's data. The network can thus pass the roaming number to network A which routes the call to the subscriber, charging for the call being billed to the subscriber in the usual way.

If the subscriber now moves to another AMPS/D-AMPS network, the operation is exactly the same.

This mode of operation, in which network A has concluded a separate commercial arrangement with every AMPS/D-AMPS network likely to be visited by the visiting subscriber, may be advantageous in simplifying commercial transactions between the networks.

All the operations described above envisage that a commercial arrangement exists between a network (e.g. network A) of the GSM system and a network (e.g. network D), or at least one network, of the AMPS/D-AMPS system. It will be noted that as far as the subscriber's home network is concerned, the HLR of the other network in the commercial arrangement is effectively acting as a VLR. Thus, if a subscriber to network D, intending to roam to network A and having been provided with a SIM card by the operator of network D for this purpose in the manner

explained above, visits network A and activates a telephone handset there using the SIM card, HLR 58 will treat HLR 40A effectively as a VLR - that is, it will treat HLR 40A in substantially the same way as it would treat one of its own VLR's if the subscriber happened to be present and activating a telephone within network D. However, although HLR 40A in this example is treated by network D as effectively being a VLR, HLR 40A is nevertheless treated as an HLR by the VLR in network A corresponding to the cell in which the subscriber is temporarily located.

Correspondingly, if a network A subscriber roaming to network D, having previously arranged this with the operator of network A and having been provided with a network D subscriber identification number for this purpose, visits network D and activates the telephone in the manner described above, network A will effectively treat HLR 58 as a local VLR - that is, in substantially the same way as it would treat one of the VLR's in its own network. However, VLR in network D which corresponds to the cell where the subscriber is temporarily located treats HLR 58 as an HLR. The same is true if the network A subscriber roams to another AMPS/D-AMPS network with which the operator of network A has concluded a commercial arrangement.

CLAIMS

1. A method of operating a cellular telephone system having local subscribers to the system ("the main system") who are respectively identified to the main system by means of respective subscriber identification numbers, these numbers being used within the main system to record the location therein of each subscriber within the main system for receiving and initiating calls and for recording associated billing information, the method comprising the steps of: providing similar identification numbers for distant subscribers who are not subscribers of the main system but are subscribers to a second cellular telephone system, each latter number being input into the main system when visited by the distant subscriber, such number not only being used within the main system to record the location therein of the subscriber for receiving and initiating calls and for recording associated billing information but also identifying the subscriber as being a subscriber subscribing to the second cellular telephone system; providing inter-system communications means between the two systems so that calls to a distant subscriber visiting the main system are routed via the second system and the communication means and the main system and thence to the location in the latter of the distant subscriber which is identified

within the main system by that subscriber's identification number, and so that calls initiated by that distant subscriber are routed via the main system; and transmitting billing information associated with calls received and/or initiated by the visiting distant subscriber to the second system and via that system to the distant subscriber.

2. A method according to claim 1, in which the main system comprises a plurality of cellular telephone networks and in which each local subscriber is a subscriber of a particular one of these networks ("the home network") so that the subscriber identification numbers of the local subscribers also identify the home networks of which they are respectively subscribers, and including the steps of detecting the presence of a local subscriber within another of the networks ("visited network") of which that subscriber is not a subscriber by means of the corresponding subscriber identification number when input into that network, responding to such detection by storing within that subscriber's home network the actual location of that subscriber within the visited network, and establishing inter-network communication means between the networks so that calls to the subscriber are routed via that subscriber's home network, the inter-network communication means, and the visited network

to the location in the visited network of the subscriber, and so that calls initiated by that subscriber are routed via the visited network, and transmitting billing information in relation to calls to or from the subscriber to the home network and then to the subscriber.

3. A method according to claim 2, in which the subscriber identification number provided to each distant subscriber is such that that subscriber is identified to one, only, of the networks ("the primary network") of the main system as being a distant subscriber, and is identified to all of the other networks of the main system as being a local subscriber subscribing to the primary network, so that calls to that subscriber when temporarily positioned in another of the networks of the main system are routed via the second system and the inter-system communication means to the other network and thence to the location of that subscriber within that other network, and so that calls initiated by that subscriber are routed via the latter network and billing information relating to calls to and/or from the subscriber is routed to the primary network and thence to the second system and then to the subscriber.

4. A method according to claim 3, in which calls to the distant subscriber when in the said other network of

the main system are routed to that network via the primary network of the main system and thence via the inter-network communication means to the said other network.

5. A method according to claim 2, in which the subscriber identification number provided to each distant subscriber is such that that subscriber is identified to each of the networks of the main system as being a distant subscriber, so that calls to that subscriber when temporarily positioned in any of the networks of the main system are routed via the second system and the inter-system communication means to that network in the main system and thence to the location of that subscriber within that network, and so that calls initiated by that subscriber are routed via the network in which the subscriber is temporarily positioned, billing information relating to calls to and/or from the subscriber being routed via the network in which the subscriber is temporarily positioned and thence to the second system and then to the subscriber.

6. A method according to any preceding claim, in which one of the systems is a GSM system and the other system is an AMPS/D-AMPS system.

7. A method according to any one of claims 2 to 4,

in which the main system is a GSM system and each of the said networks is a GSM network, and in which the second system is an AMPS/D-AMPS system.

8. A method according to claim 6, in which the said one system is the main system.

9. A method according to claim 7 or 8, in which the respective subscriber identification numbers of the local subscribers are input in to the main system by means of tokens, and in which the step of providing subscriber identification numbers to the distant subscribers comprises the step of providing them with respective tokens for inputting those numbers into the main system.

10. A method according to any one of claims 6 to 9, in which the inter-system communications means operates in accordance with IS.41.

11. A method according to any one of claims 6 to 10, in which the AMPS/D-AMPS system comprises a plurality of AMPS/D-AMPS networks inter-connected in accordance with IS.41.

12. A method according to claim 8 or 9, in which each token is a smart card.



13. A cellular telephone arrangement, comprising a main cellular telephone system having local subscribers to the system who are identified to the system by means of respective subscriber identification numbers to be input into the system, these numbers being used within the system to record the location of each subscriber within the system for receiving and initiating calls and for recording associated billing information; reading means within the main system for reading subscriber identification number input into the system by a distant subscriber who is not a subscriber to the main system but is a subscriber to a second cellular telephone system, such subscriber identification number identifying the distant subscriber as being a subscriber to the second system but temporarily authorised within the main system and being used within the main system to record the location of the distant subscriber within the main system for receiving and initiating calls and for recording associated billing information; inter-system communication means providing communication between the main system and the second system so that calls to the distant subscriber in the main system are routed from the said other system and via the communication means and the main system and thence to the location of the distant subscriber therein, and so that calls initiated by that distant subscriber are routed via the main system; and billing means for

transmitting billing information associated with calls received or initiated by the visiting distant subscriber to the second system and thence via that system to the subscriber.

14. An arrangement according to claim 13, in which the main system comprises a plurality of cellular telephone networks and in which each local subscriber is a subscriber to a particular one of these networks ("the home network") so that the subscriber identification numbers of the local subscribers also identify the home networks of which they are respectively subscribers, and including means responsive to the subscriber identification number when input into a network ("visited network") with which a local subscriber is not a subscriber to detect the presence of the local subscriber in the visited network, storing means responsive to the detecting means and operative to store within the subscriber's home network the actual location of that subscriber within the visited network, and means for establishing an inter-network communication link between the networks so that calls to the subscriber are routed via that subscriber's home network, the inter-network communication link and the visited network to the location in the visited network of the subscriber, and so that calls initiated by that subscriber are routed via the

visited network, and billing means for transmitting to the home network billing information which is related to calls to or from the subscriber and which is then billed to the subscriber.

15. An arrangement according to claim 14, in which the subscriber identification number provided to each distant subscriber is such that that subscriber is identified to one, only, of the networks ("the primary network") of the main system as being a distant subscriber, and is identified to all of the other networks of the main system as being a local subscriber of the said main network, and including means for routing calls to that subscriber, when temporarily positioned in another of the networks of the main system, via the second system and the inter-system communication means to the other network and thence to the location of that subscriber within that other network, means for routing calls initiated by that subscriber via the latter network, and billing means for routing billing information relating to calls to and/or from the subscriber to the primary network and thence to the second system and then to the subscriber.

16. An arrangement according to claim 15, including means operative to route calls to the distant subscriber when in the said other network of the main system via the primary

network of that system and thence via the inter-network communications link to the said other network.

17. An arrangement according to claim 14, in which the subscriber identification number provided to each distant subscriber is such that that subscriber is identified to each of the networks of the main system as being a distant subscriber, so that calls to that subscriber when temporarily positioned in any of the networks of the main system are routed via the second system and the inter-system communication means to that network in the main system and thence to the location of that subscriber within that network, and so that calls initiated by that subscriber are routed via the network in which the subscriber is temporarily positioned, billing information relating to calls to and/or from the subscriber being routed via the network in which the subscriber is temporarily positioned and thence to the second system and then to the subscriber.

18. An arrangement according to any one of claims 13 to 17, in which one of the systems is a GSM system and the other system is an AMPS/D-AMPS system.

19. An arrangement according to any one of claims 14 to 16, in which the main system is a GSM system and each of

the said networks is a GSM network, and in which the second system is an AMPS/D-AMPS system.

20. An arrangement according to claim 18, in which the said one system is the main system.

21. An arrangement according to claims 18 or 19, in which the respective subscriber identification numbers of the local subscribers are input in to the main system by means of tokens, and in which the subscriber identification numbers input in to the main system by each distant subscriber are input by means of tokens.

22. An arrangement according to claim 21, in which each token is a smart card.

23. An arrangement according to any one of claims 18 to 22, in which the inter-system communications means operates in accordance with IS.41.

24. An arrangement according to any one of claims 18 to 23, in which the AMPS/D-AMPS system comprises a plurality of AMPS/D-AMPS networks inter-connected in accordance with IS.41.

25. A cellular telephone arrangement, comprising: a

primary cellular telephone network and a distant cellular telephone network; the primary network having local subscribers to that network who are respectively identified to that network by means of respective subscriber identification numbers; the distant network having distant subscribers to that network who are respectively identified to that network by means of respective subscriber identification numbers; each network having a respective home location register ("HLR") for storing subscriber data relating to each subscriber to that network including the respective subscriber identification numbers; each network having a respective plurality of visitor location registers ("VLR's") each corresponding to a particular cell of the network; means within each network for responding to the input into a particular cell of that network of the subscriber identification number of a subscriber to that network to access the corresponding stored subscriber data from the HLR of that network and to store it temporarily in the VLR of that cell for use in relation to calls made to or from that subscriber via that cell and for recording associated billing information; means for storing, in the HLR of the primary network, data ("visiting subscriber data") relating to a distant subscriber intending to visit the primary network, the visiting subscriber data including a visiting subscriber identification number provided to the

visiting distant subscriber for that purpose and also including corresponding address data for addressing at least some of the subscriber data relating to the visiting distant subscriber which is stored in the HLR of the distant network; means for storing, in the HLR of the distant network, address data relating to the visiting distant subscriber for addressing at least some of the visiting subscriber data stored in the HLR of the primary network; means responsive to the input into a cell of the primary network of the visiting subscriber identification number for accessing the corresponding visiting subscriber data in the HLR of the primary network; means responsive to the corresponding address data in the HLR of the primary network for accessing at least some of the subscriber data relating to that subscriber and stored in the HLR of the distant network; means for storing the accessed data from the HLR's of both networks in the VLR of the said cell for use in relation to calls to and from the visiting distant subscriber via that cell and for recording associated billing information; means in the distant network responsive to calls made to the visiting distant subscriber via the distant network to route such calls to the visiting distant subscriber via the distant network and the main network using the data temporarily stored in the VLR of the cell where the visiting distant subscriber is temporarily located; means in the primary

network responsive to a call made by the visiting distant subscriber to route that call via the cell where the visiting distant subscriber is temporarily located and via the main network; and means in the primary network and responsive to the data temporarily stored in the VLR of the cell where the visiting distant subscriber is temporarily located for transmitting the recorded billing information to the distant network for the account of the distant subscriber.

26. An arrangement according to claim 25, in which the primary network is one of a plurality of similar networks which are linked by inter-network connection means to form a main system, and in which each visiting subscriber identification number issued by the primary network of the main system identifies the visiting distant subscriber to each of the other networks of the main system as being a subscriber to the primary network; and including means in each said other network of the main system for responding to the input into a cell of that other network of the visiting subscriber identification number to access at least some of the visiting subscriber data stored in the HLR of the primary network and to access at least some of the subscriber data in the HLR of the distant network relating to the visiting distant subscriber and to store the accessed data from the said HLR's in the VLR of the



said other network corresponding to the cell where the visiting distant subscriber is temporarily located; means in the distant network responsive to a call to the visiting distant subscriber to route the call to the visiting distant subscriber in the said other network in the main system using the data temporarily stored in the VLR of that other network corresponding to the cell where the visiting distant subscriber is temporarily located; means in the said other network of the main system responsive to a call by the visiting distant subscriber to route that call via the primary network of the main system using the data temporarily stored in the VLR of the cell where the visiting distant subscriber is temporarily located; and means in the said other network of the main system, and responsive to the data temporarily stored in the VLR of the cell where the visiting distant subscriber is temporarily located, for accumulating billing information relating to such calls and for transmitting that billing information to the primary network of the main system and thence to the distant network for the account of the distant subscriber.

27. An arrangement according to claim 25, in which the primary network is every one of a plurality of similar networks which are linked by inter-network connection means to form a system.

28. An arrangement according to any one of claims 25 or 27, in which the primary and distant networks are of respectively different types, one type being a GSM type of network and the other type being an AMPS/D-AMPS type of network.

29. An arrangement according to claim 28, in which the subscriber identification numbers of subscribers to the GSM network are input into the network by means of respective smart cards.

30. An arrangement according to claim 29, in which the primary network is the GSM network and in which the visiting subscriber identification number provided to the visiting distant subscriber is provided by means of a smart card for inputting the number into the GSM network.

31. A method of operating a cellular telephone system, substantially as described with reference to the accompanying drawings.

32. An arrangement of cellular telephone systems, substantially as described with reference to the accompanying drawings.

1616S

**Relevant Technical fields**

(i) UK CI (Edition )

L

H4K: KY4D14I; KY4D14R

(ii) Int CI (Edition 5 )

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H04Q

**Search Examiner**

A L STRAYTON

**Databases (see over)**

(i) UK Patent Office

(ii)

**Date of Search**

15 SEPTEMBER 1993

Documents considered relevant following a search in respect of claims

ALL

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
X	GB 2262203 A Entire document	1, 13
X	EP 0379642 A2 Pages 1-15, 41, 45-47, 51-59 (is complete specification without computer programs)	1, 13

Category	Identity of document and relevant passages	Relevance to claim
	49	

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